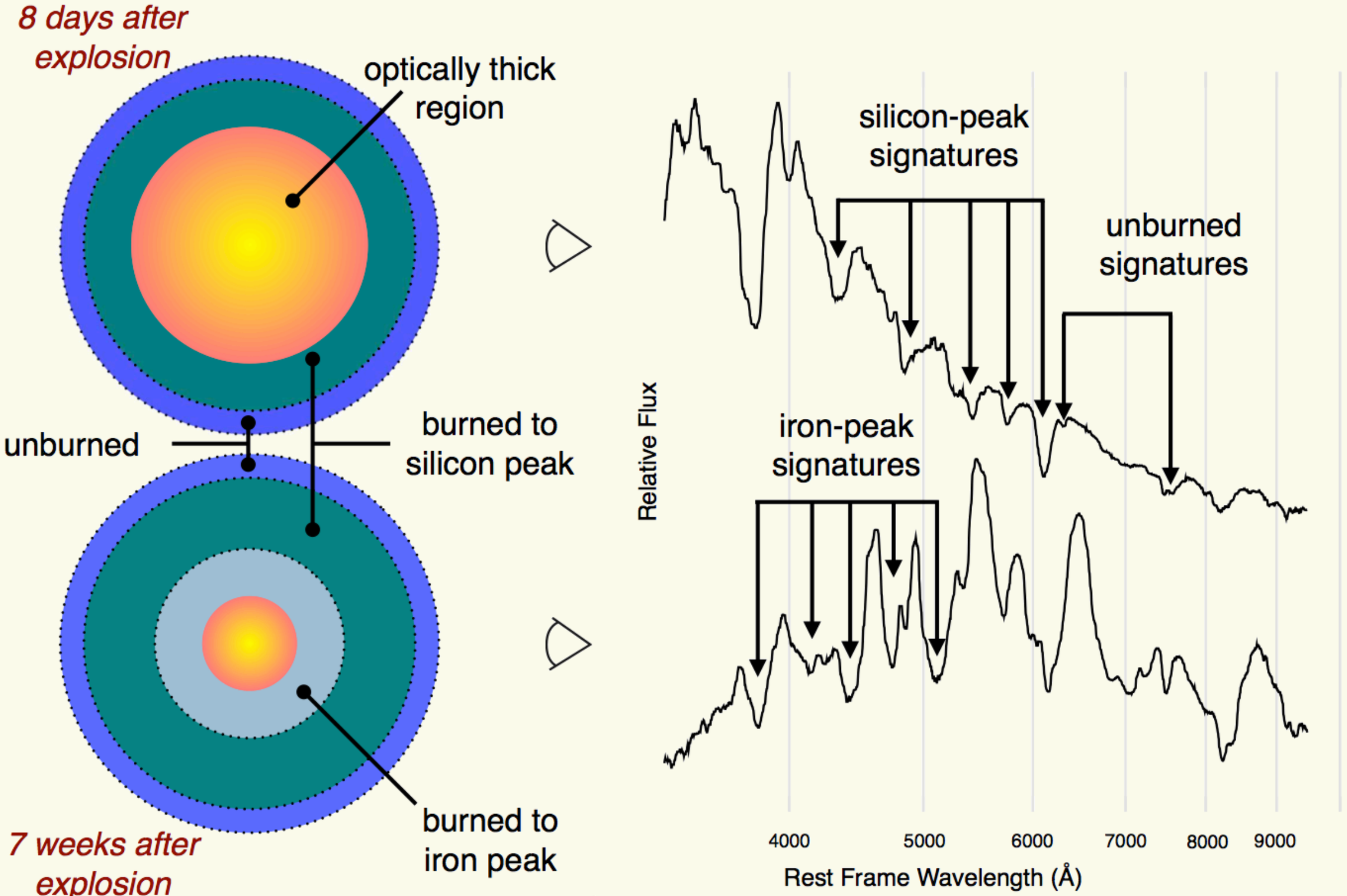
"Twin" Supernovae with SNfactory

Hannah Fakhouri
July 28, 2011

Spectra are a window into the explosion physics



Thomas, 2011

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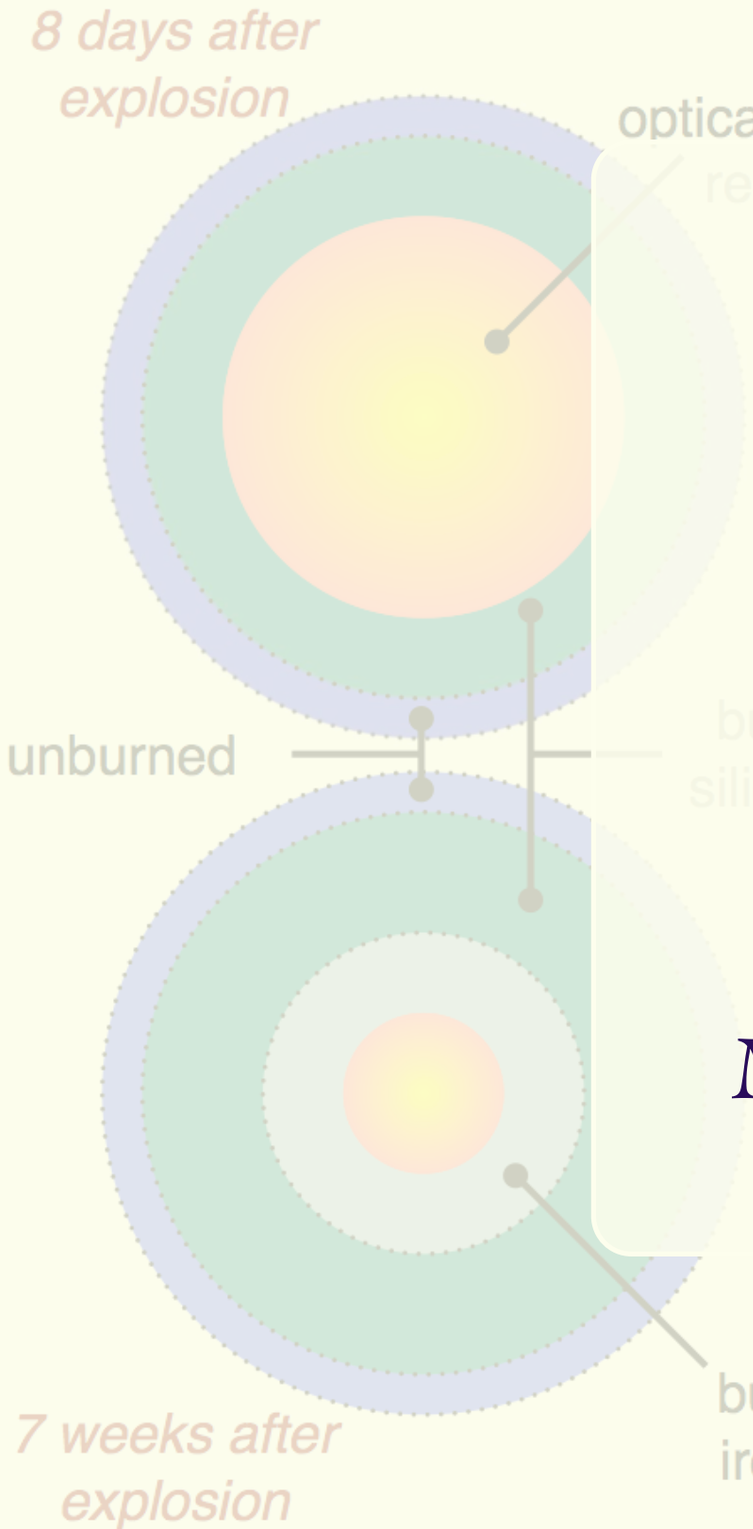
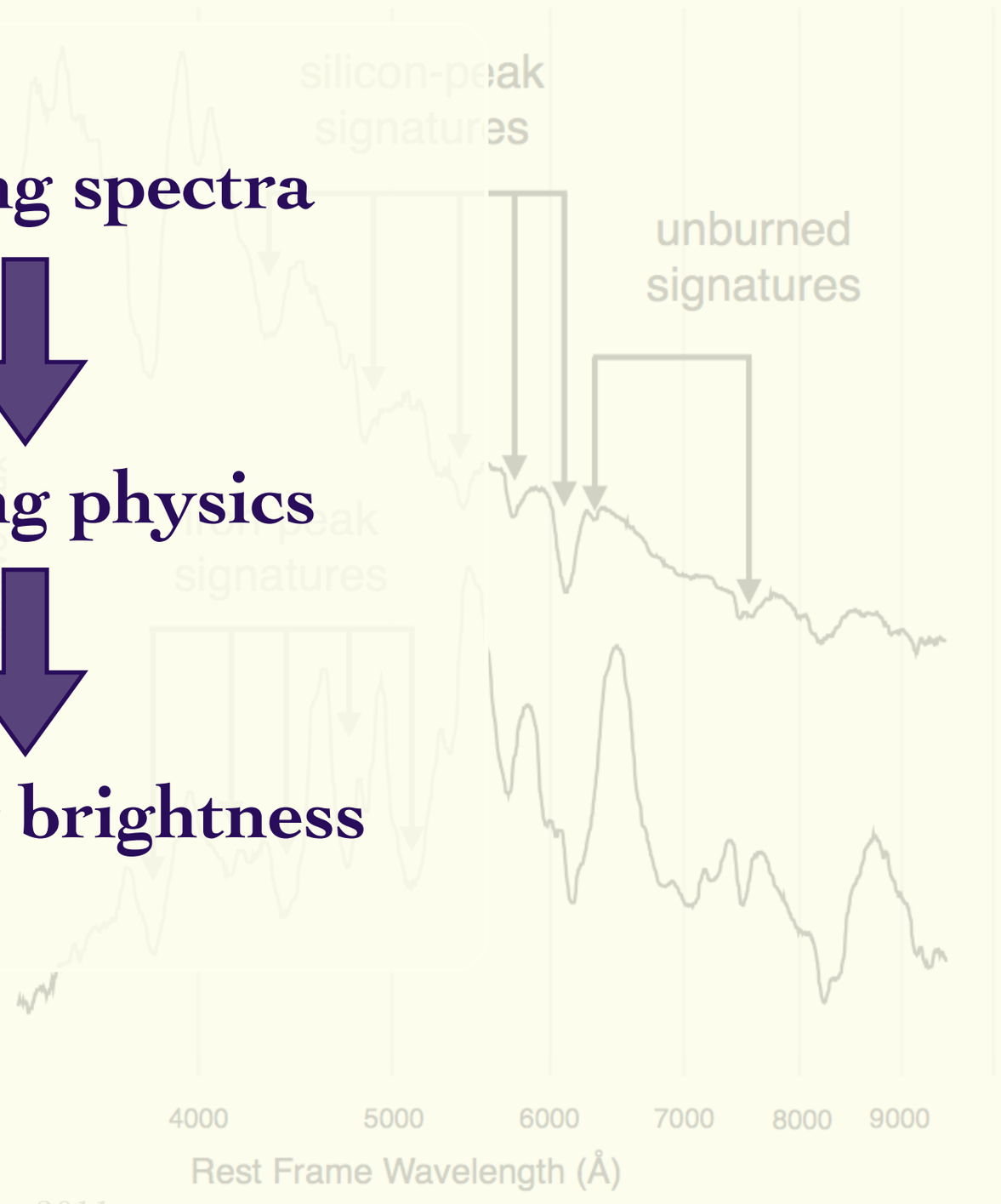


Matching spectra

Matching physics

Matching brightness



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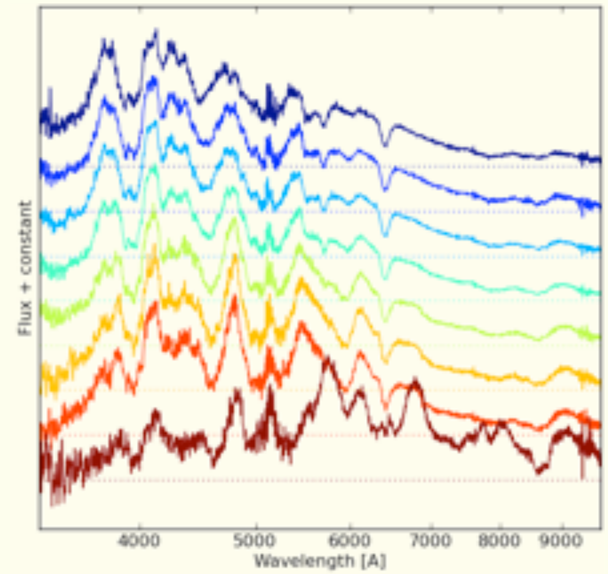
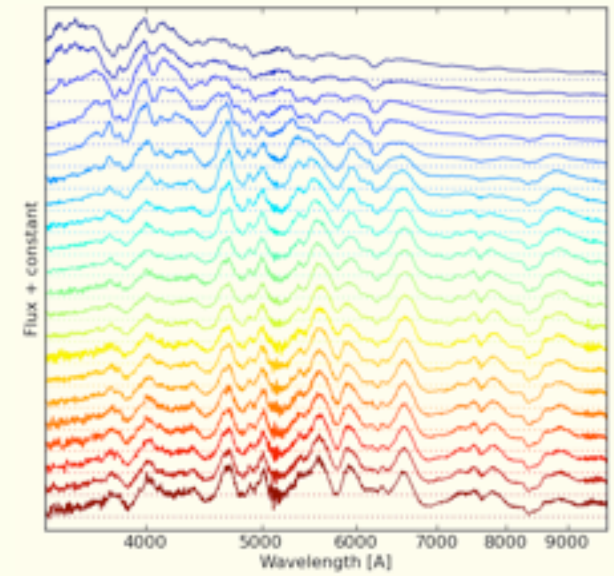
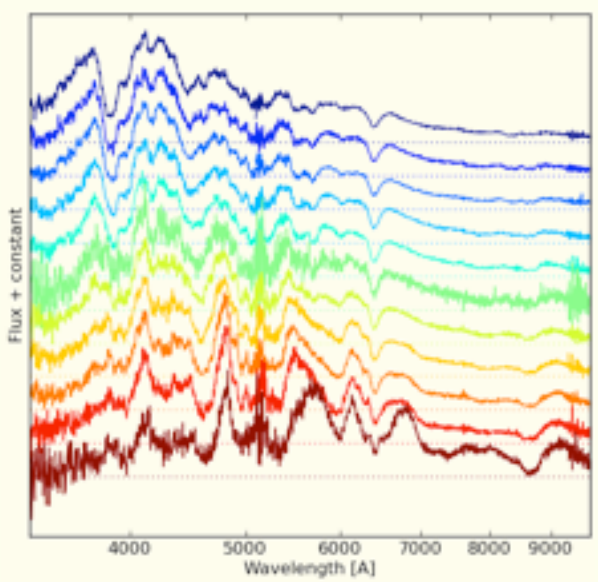
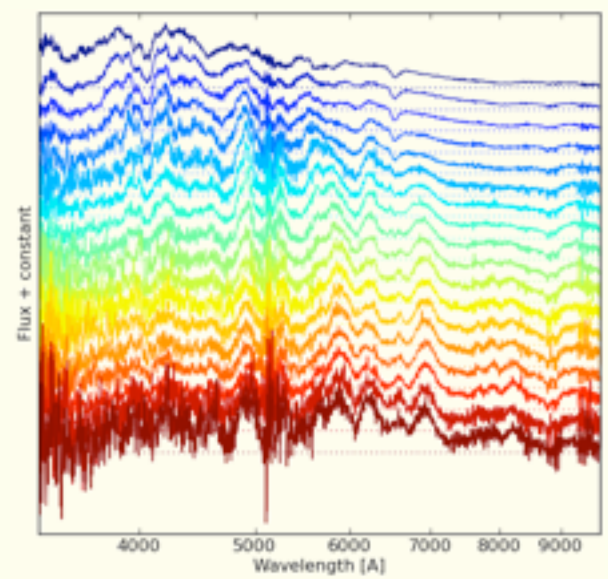
Nearby Supernova Factory:

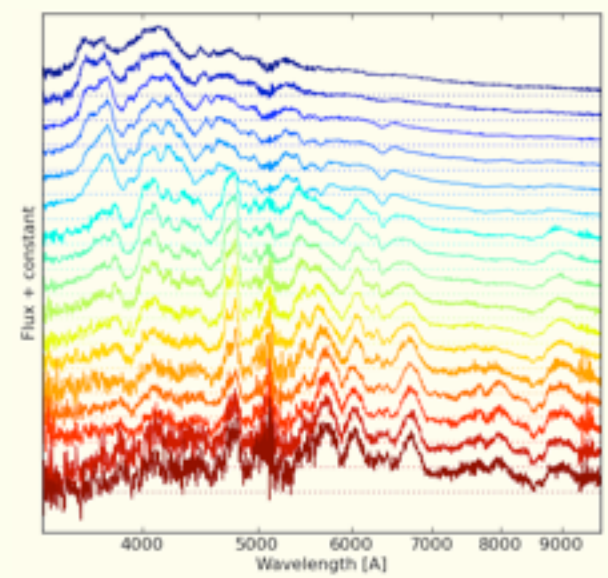
Spectrophotometric Timeseries

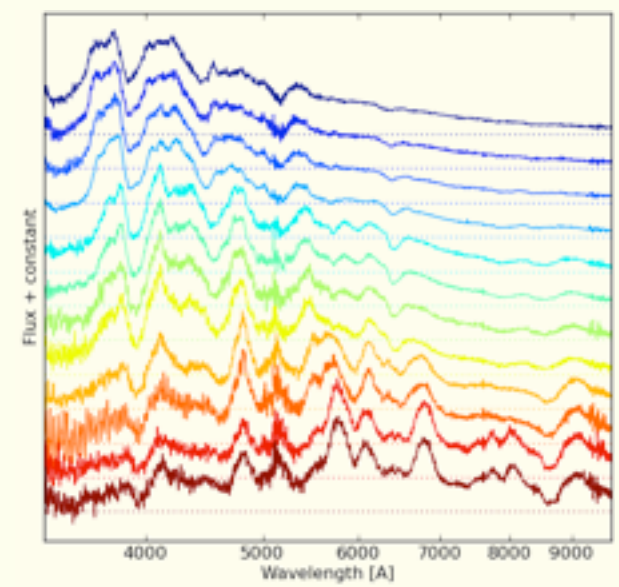


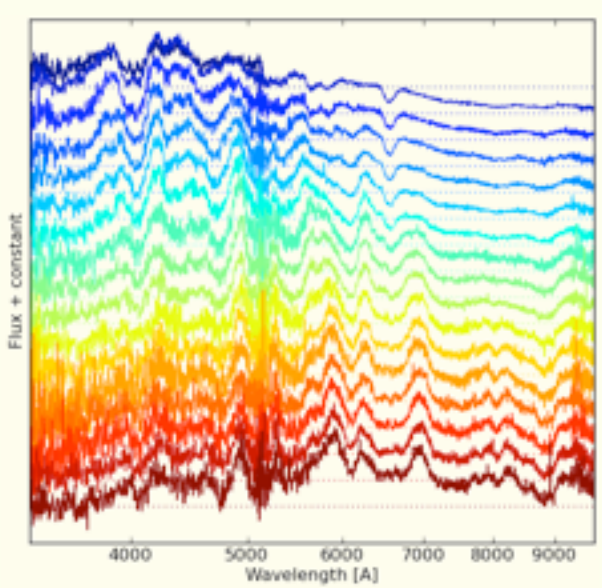


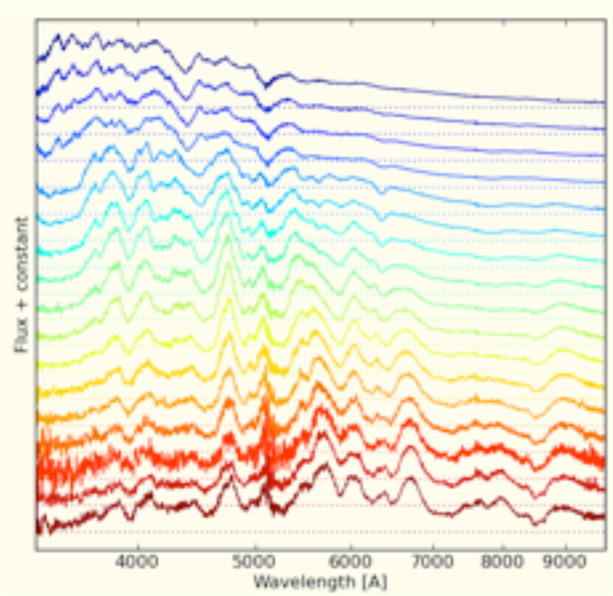


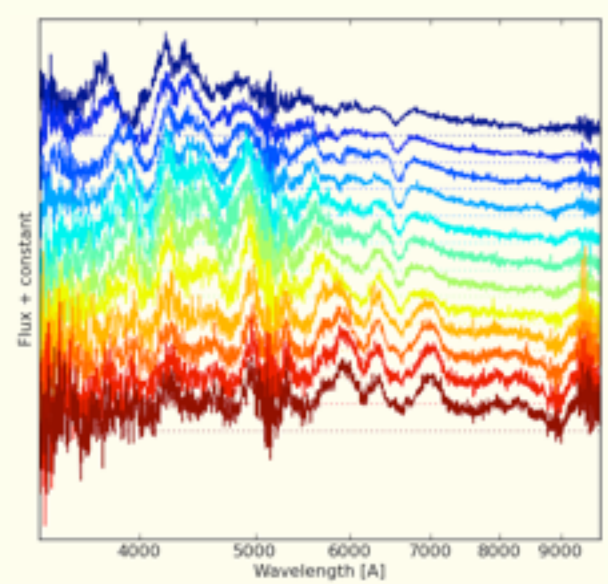


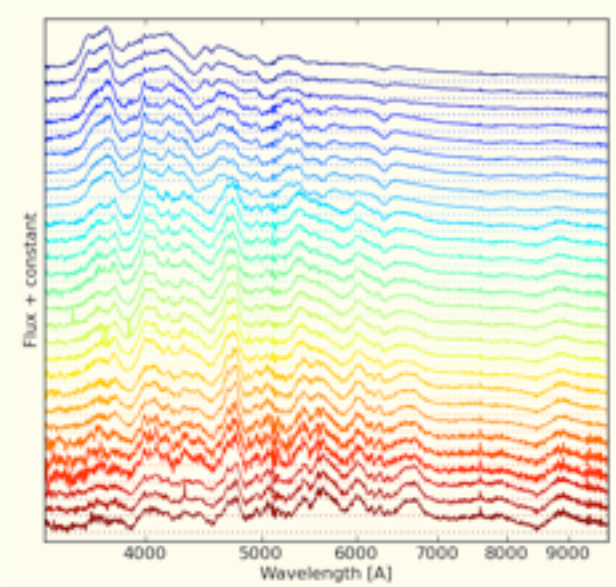












Prepare the timeseries

- Convert spectra in restframe
  Galactic extinction corrected; deredshifted,
  flux corrected for D_L

- Gaussian Process Regression
  Smoothing, interpolation, covariance

- Determine scale factor
  Spectrophotometry -> scale factor =
  brightness difference

Gaussian Process Regression

Kernel function:

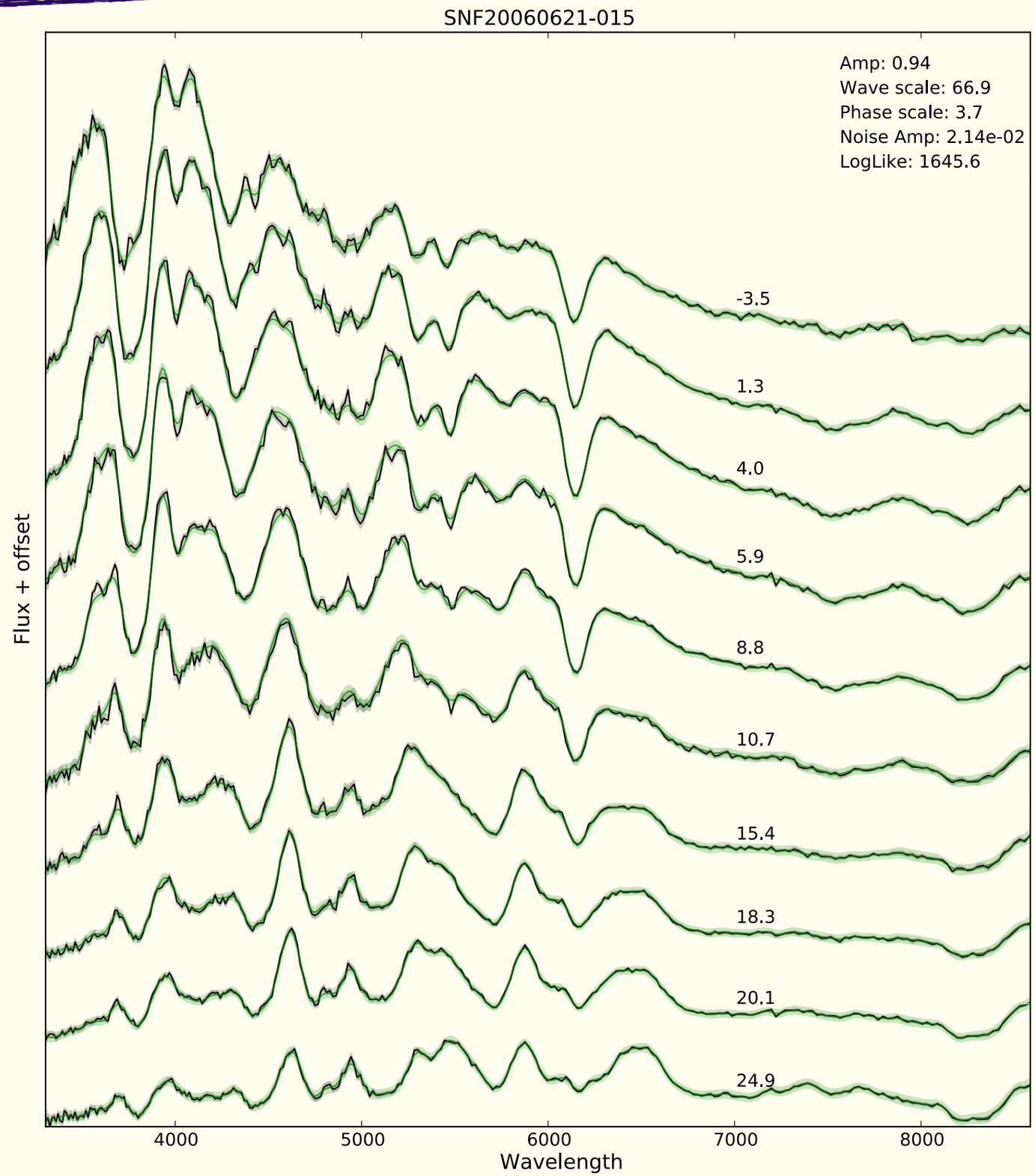
Form of data covariance

- Amplitude
- Wavelength length scale
- Phase length scale
- Noise amplitude

Use GPR results to

- Smooth spectra
- Interpolate to phase grid
- Estimate covariance

Gaussian Processes for Machine Learning
(Rasmussen & Williams)
http://www.gaussianprocess.org/gpml/



Scale factor: κ

For each pair of SNe:

One parameter, κ, over all phases & wavelengths

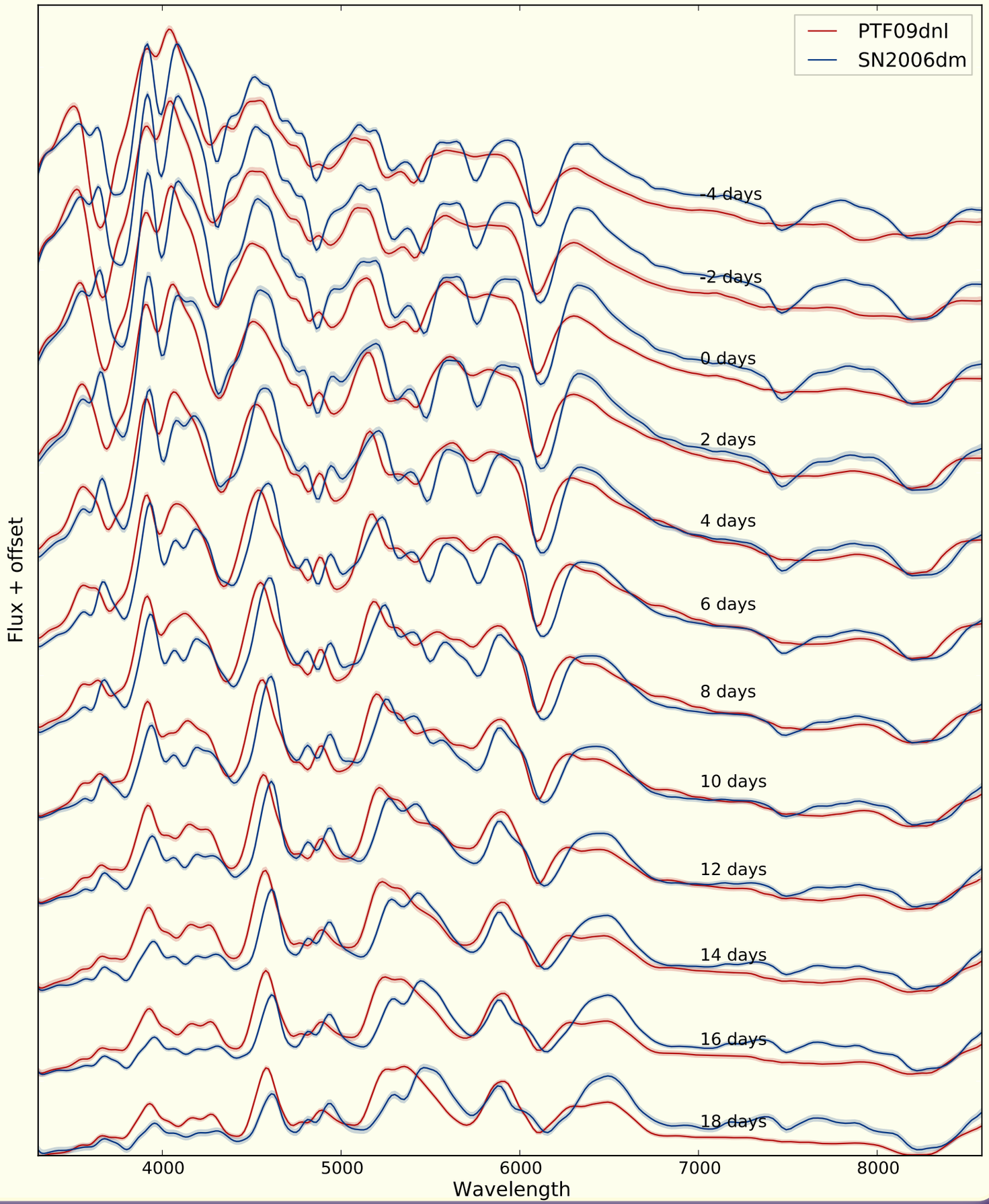
$$\chi^2_{ij} = \sum_p \sum_\lambda \frac{[\mathcal{L}_i(\lambda,p) - \kappa\mathcal{L}_j(\lambda,p)]^2}{\sigma_i^2(\lambda,p) + \kappa^2\sigma_j^2(\lambda,p)}$$

Pairs are "twins" if spectra match

Twins are standard candles if:

$\kappa = 1 \longleftrightarrow \Delta M = 0$

$$\Delta M = -2.5 log_{10}(\mathcal{L}_i/\mathcal{L}_j) = -2.5 log_{10}(\kappa)$$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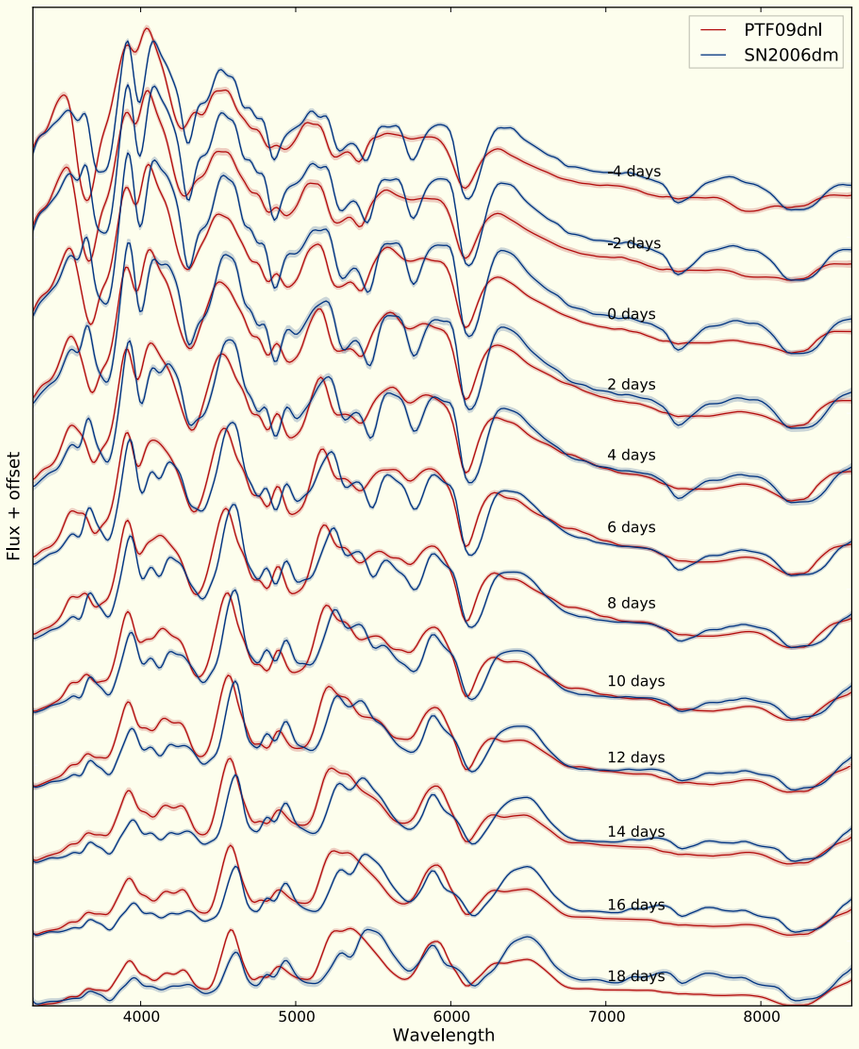
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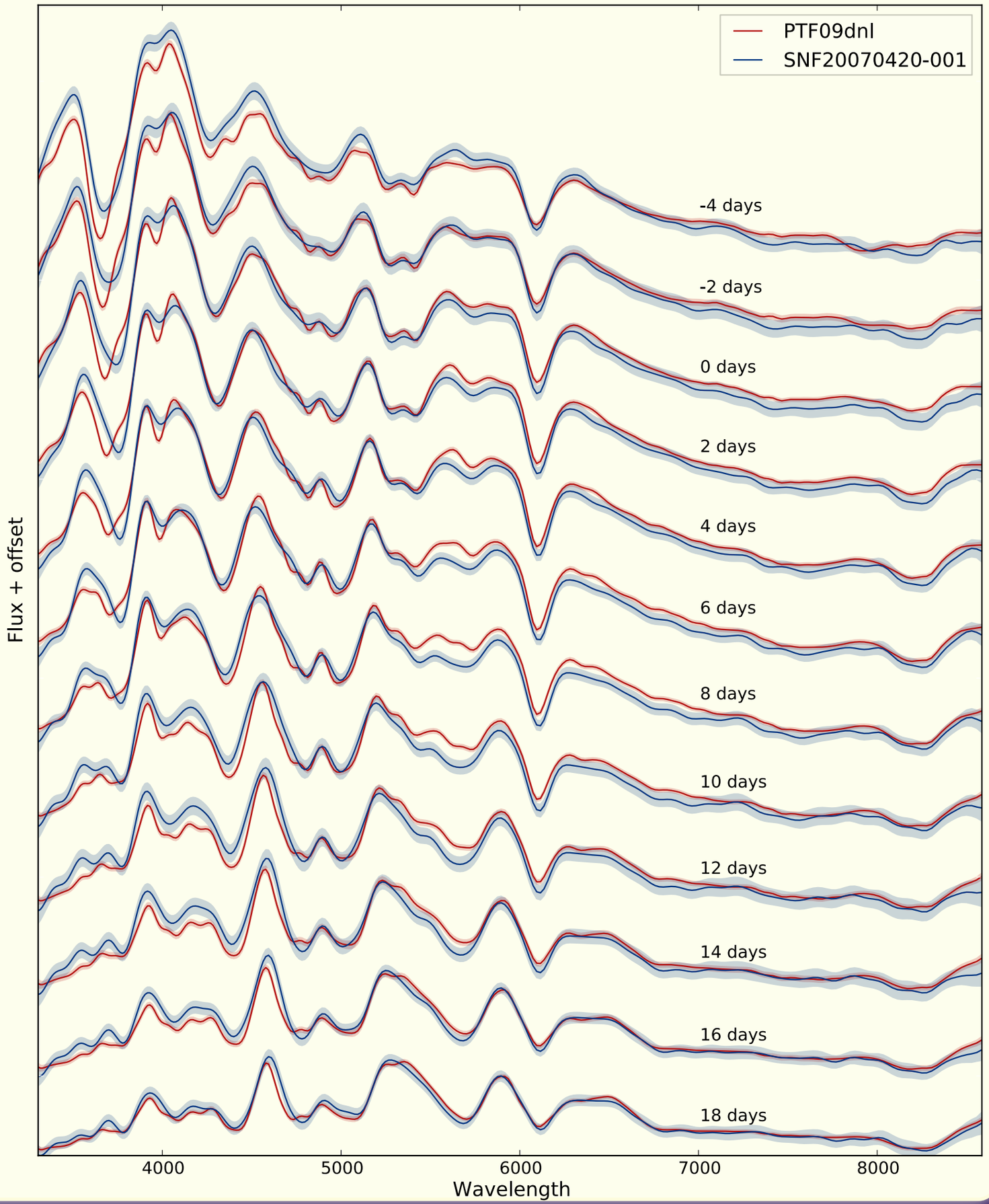
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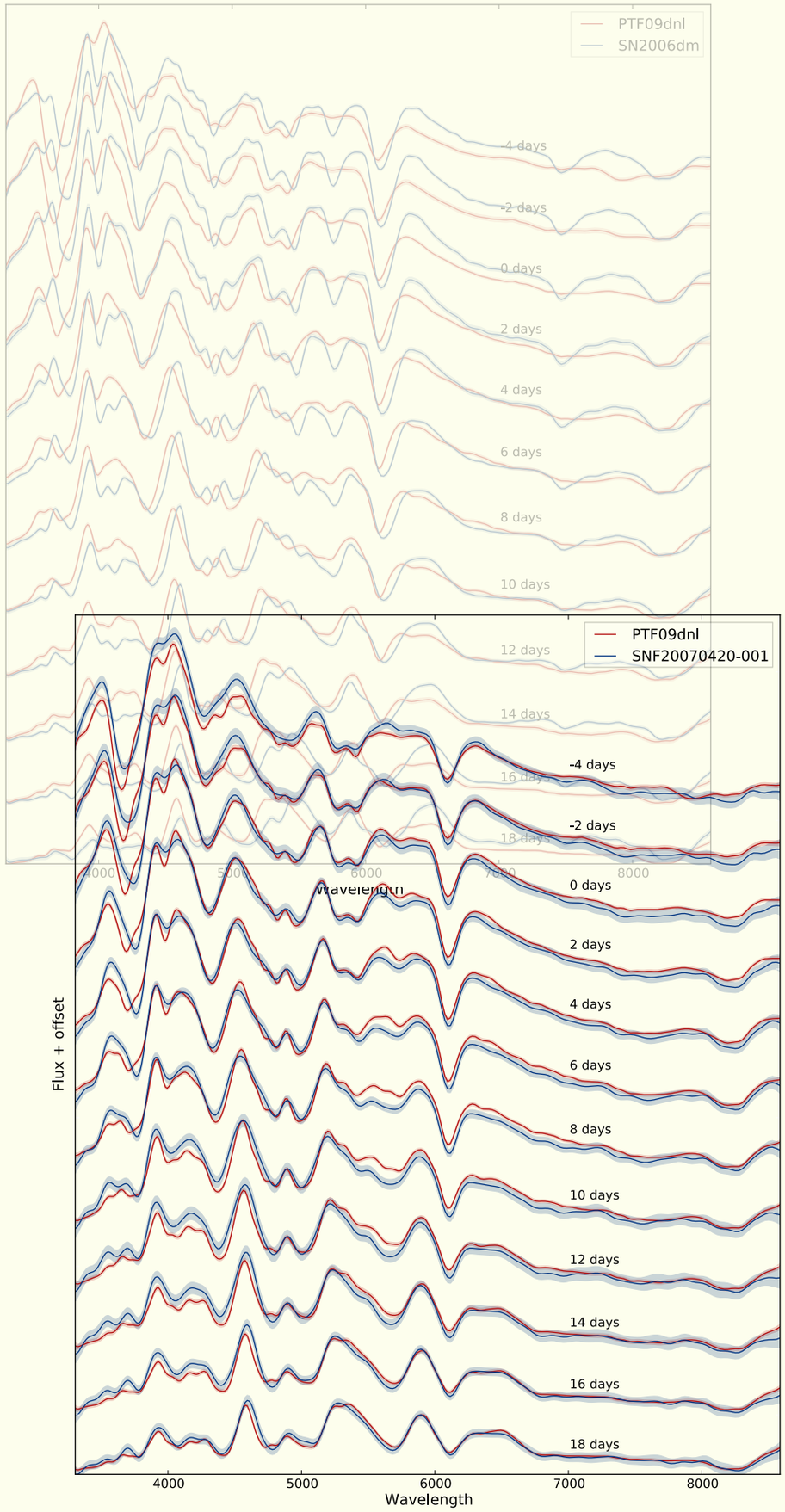
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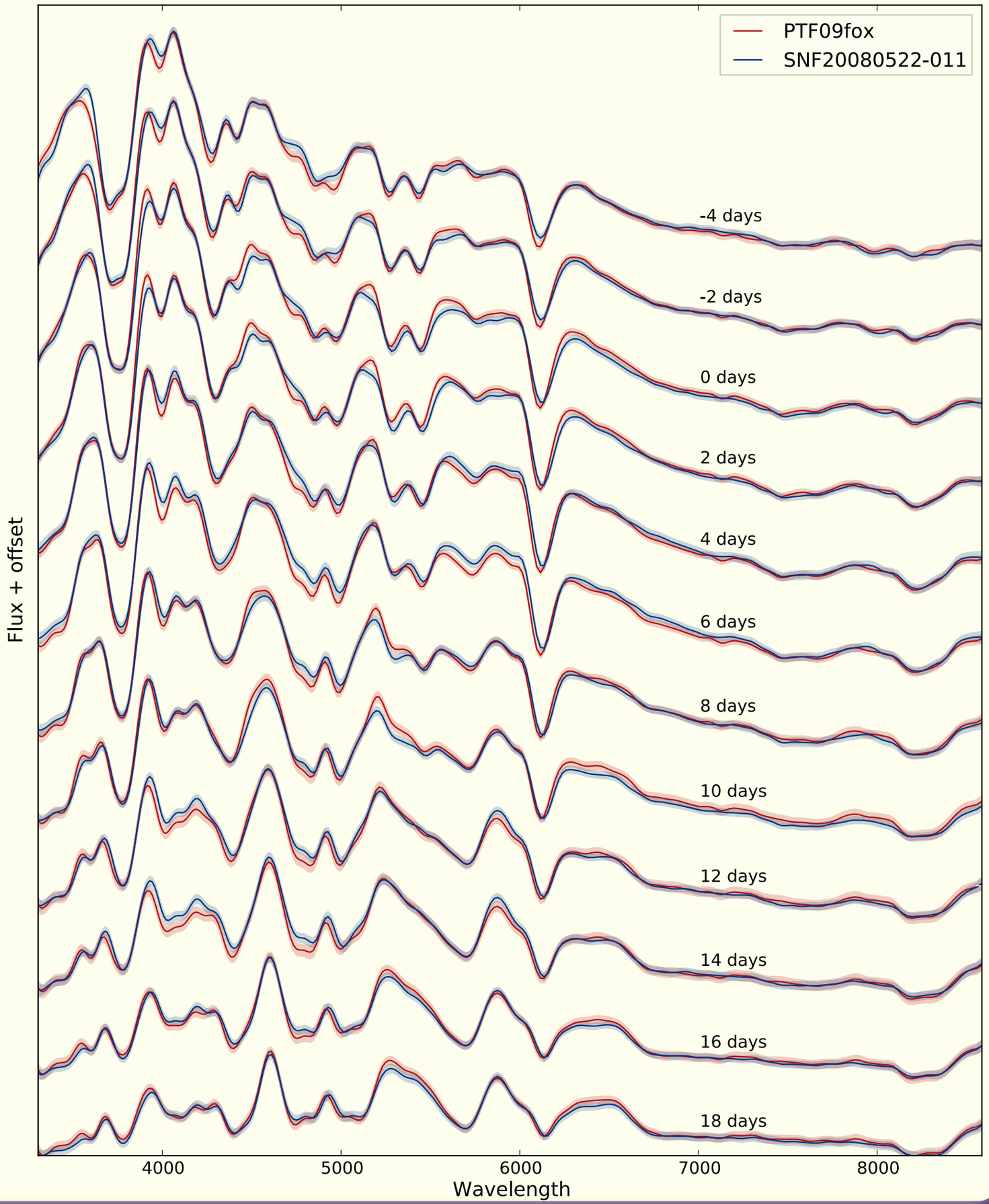
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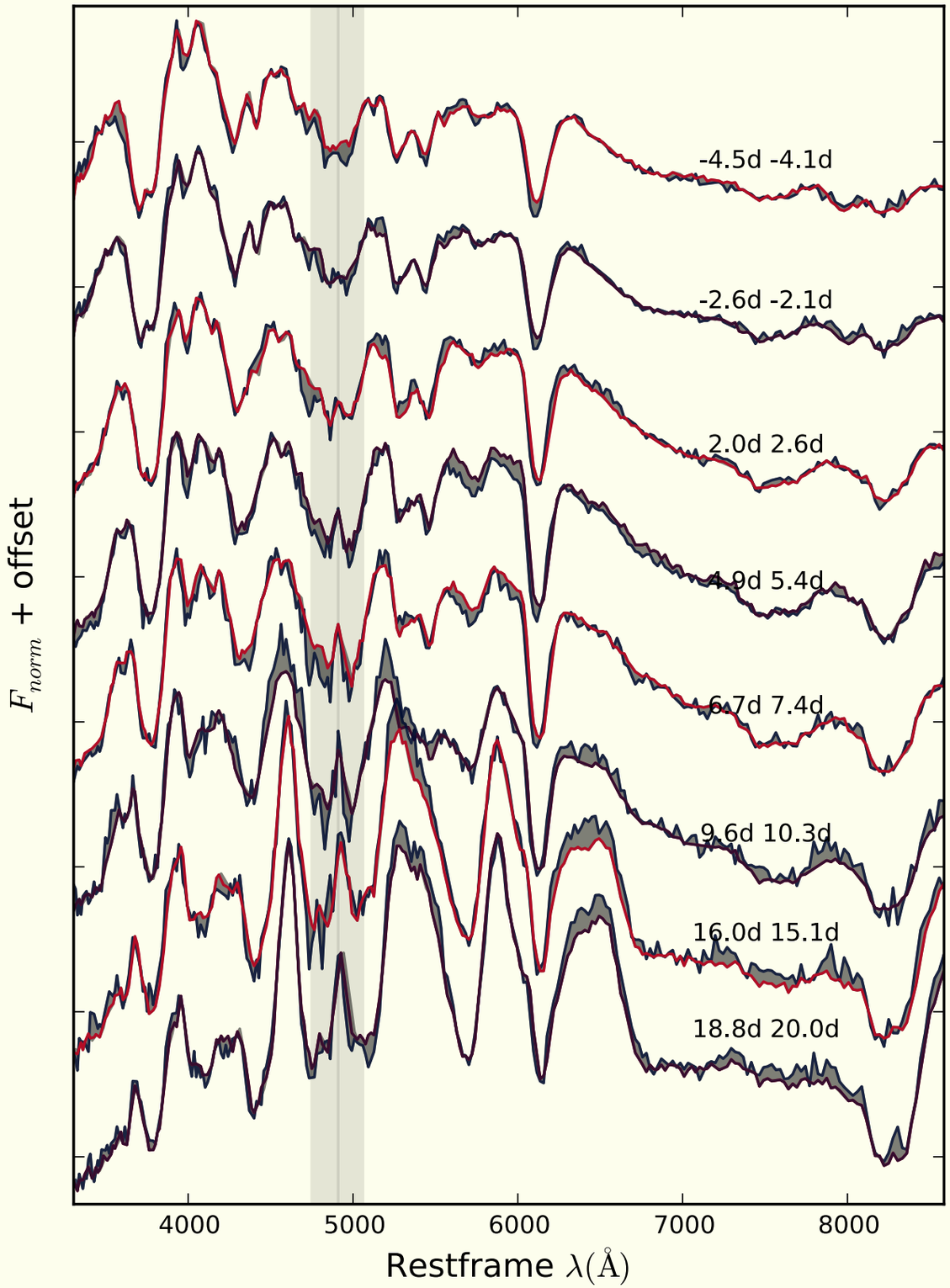
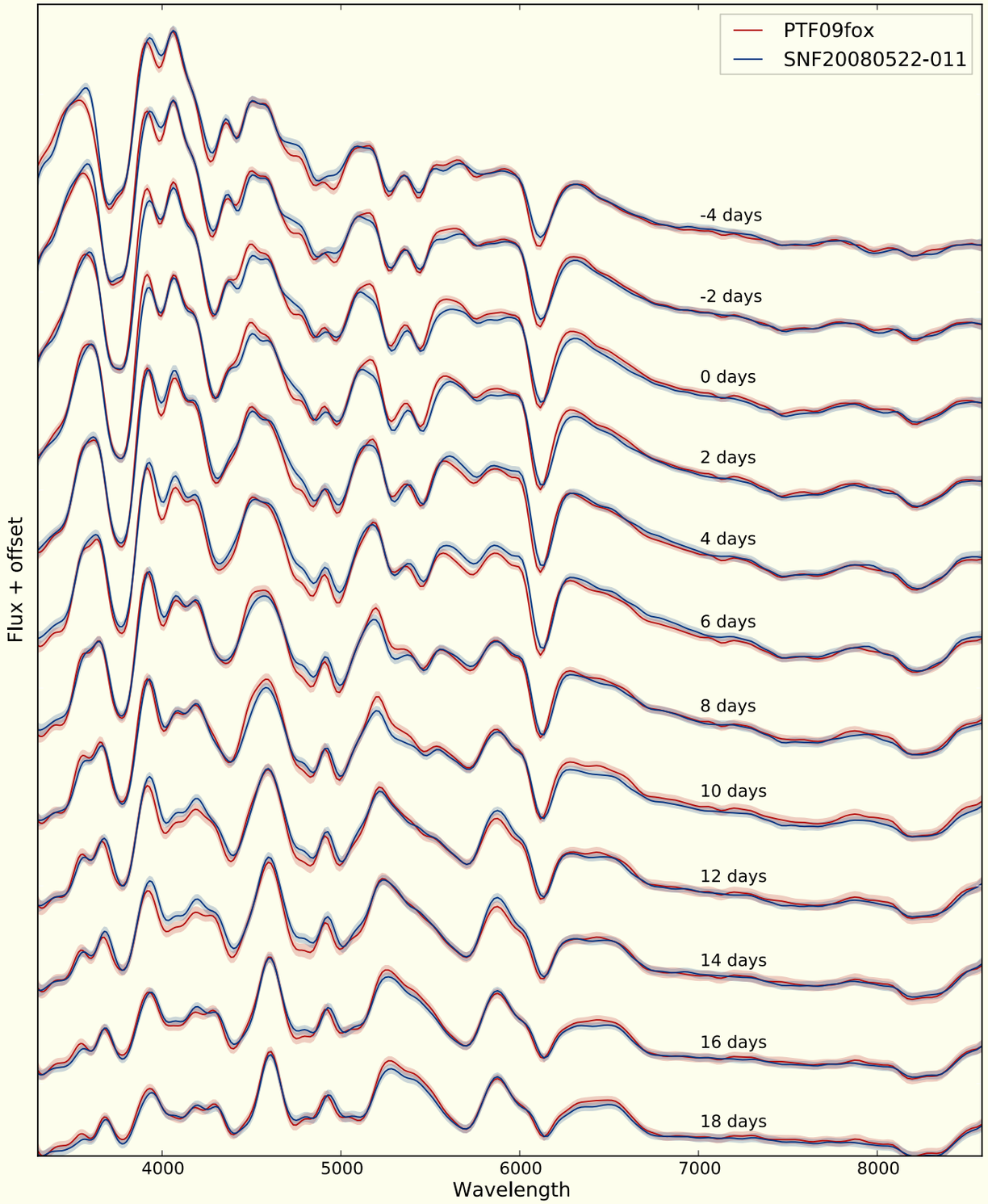
True flux comparison



GPR predicted flux comparison

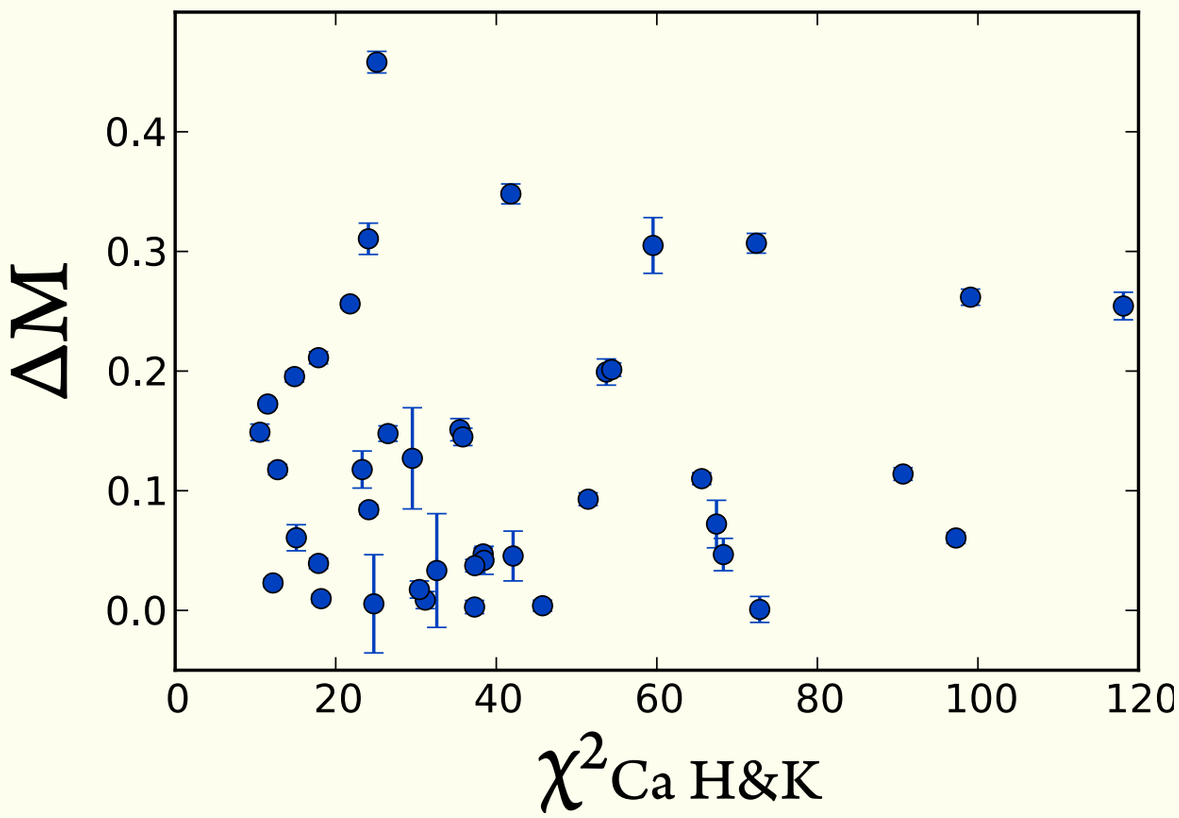


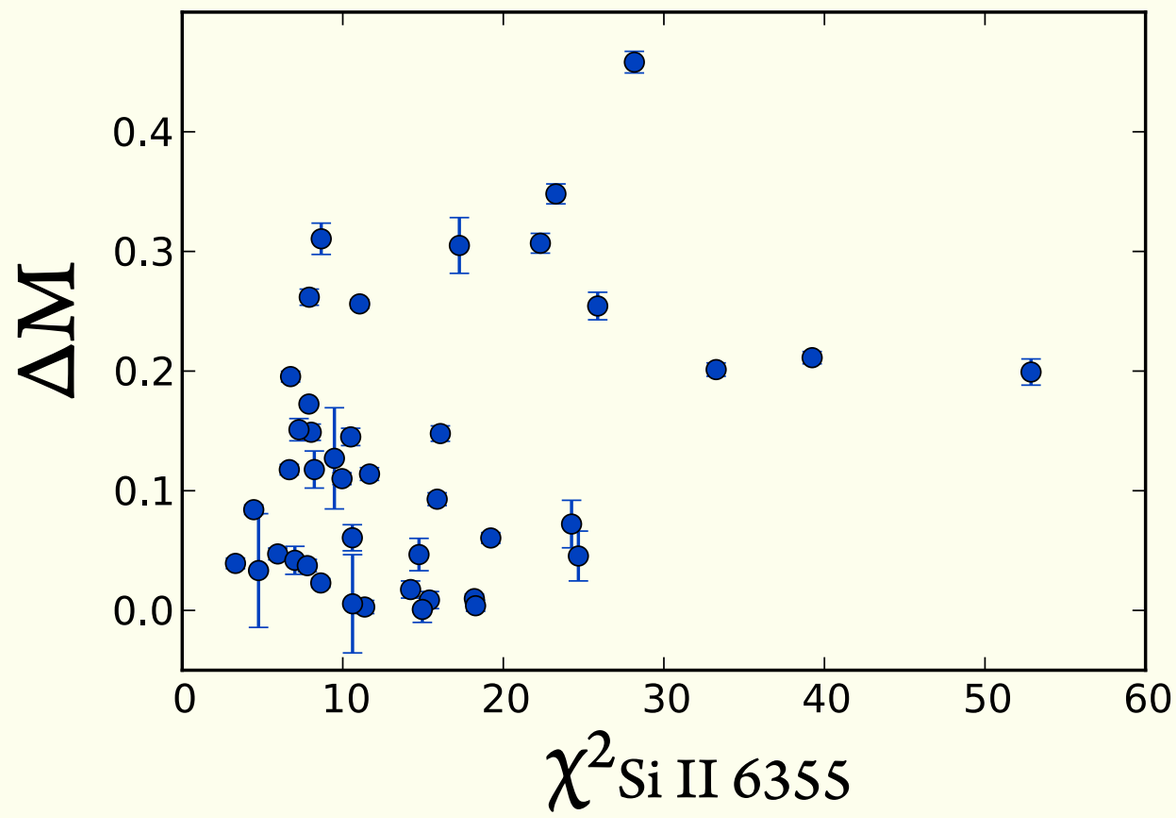
Preliminary Results

Based on GPR done on Ca H&K, Si II 6355 features

Calculate χ^2 from GPR predicted flux and covariance

Cuts on these two values yield low-ΔM sample





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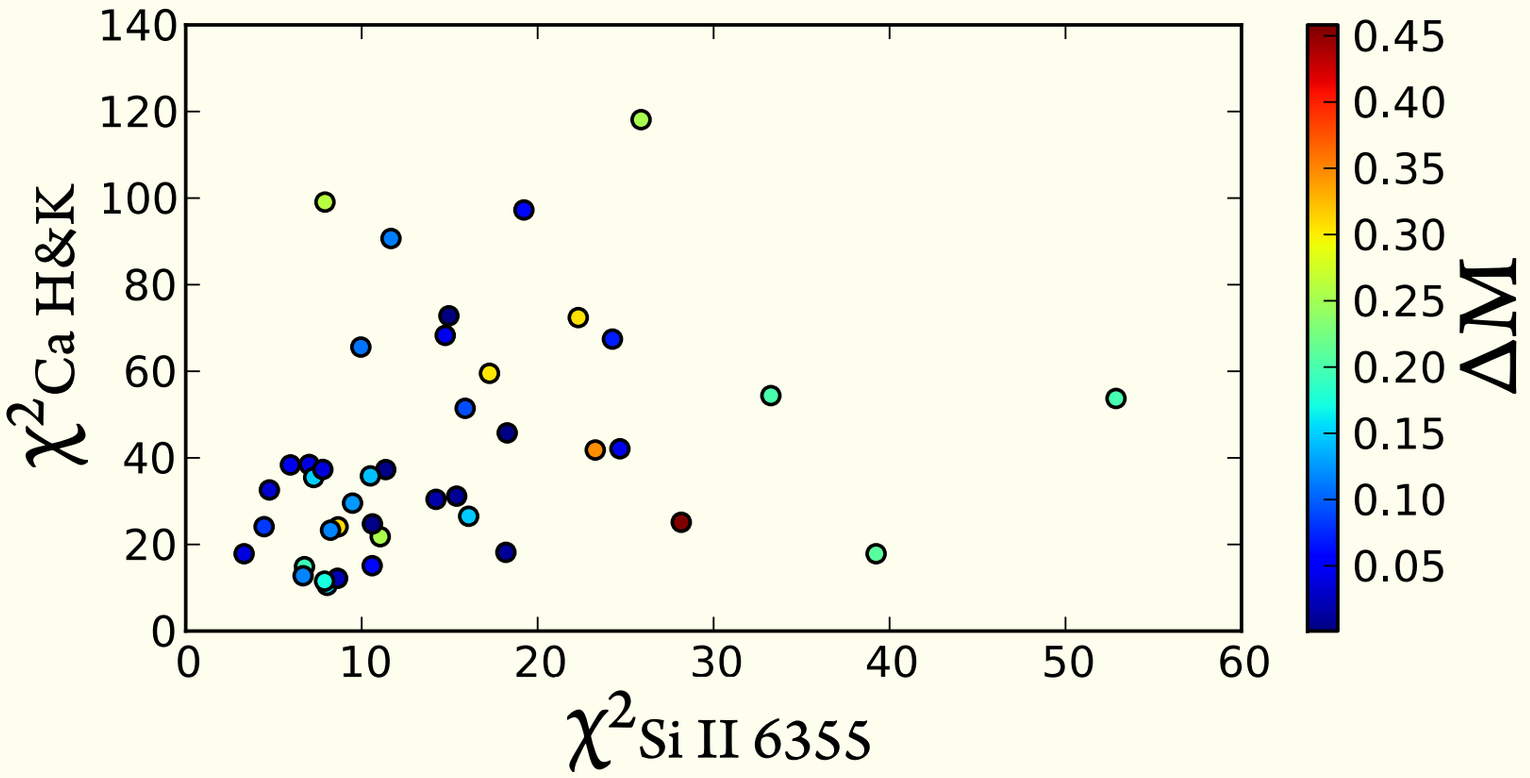


Next Steps

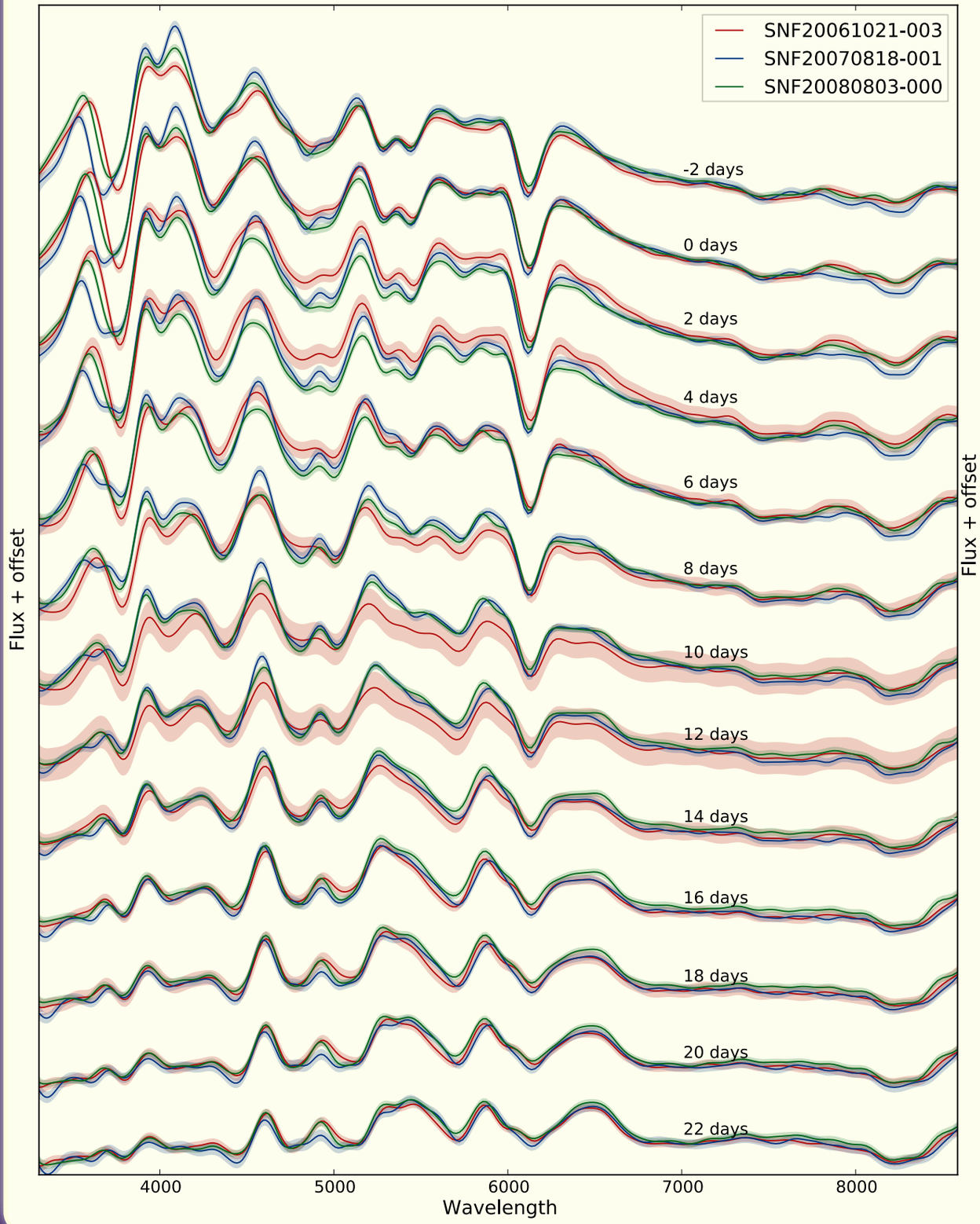
- Finalize kernel choice for GPR
- Determine twinness metric; χ^2?
- Apply host galaxy dust correction
- Unblind to full sample
- Test effects of limited phase consideration

Applicability to high-z

- Matching low-z to existing good quality high-z spectra
  Difficulties with host contamination and flux calibration
- Obtain spectrophotometric observations at high-z
  Can we do without full timeseries?
  What would signal to noise requirements be?

Thank You

Triplets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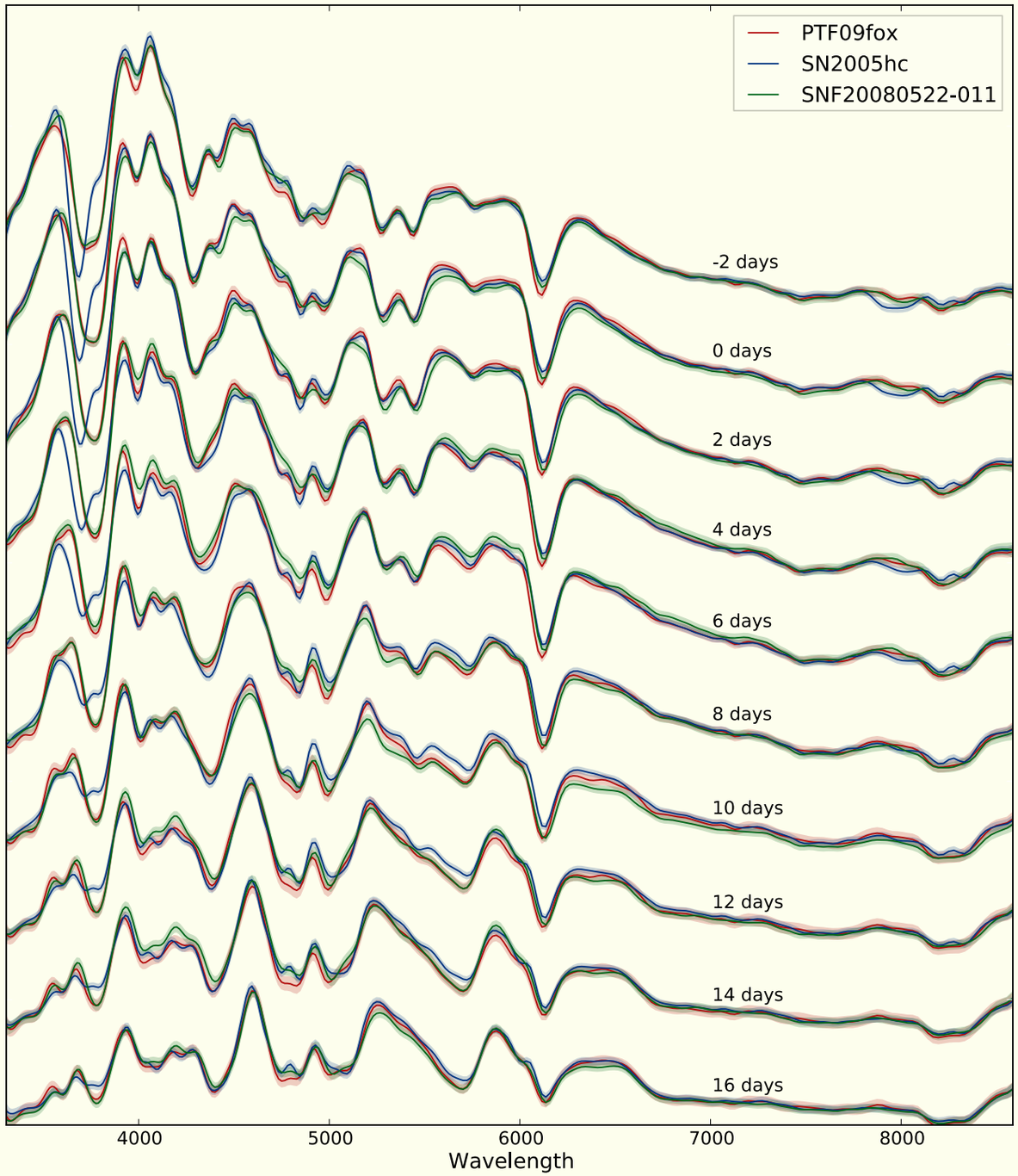
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